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ABSTRACT

A path analytic model of state test anxiety was tested in 169 college students who were enrolled in statistics courses. Variables in the model included gender, mathematics ability, trait test anxiety (trait worry and trait emotionality as separate variables), statistics course anxiety, statistics achievement (scores on midterm examinations), perceived test difficulty, and state test anxiety (state worry and state emotionality) measured at the time the final examination was taking place. Female students reported higher trait test anxiety and statistics course anxiety than did males. Mathematics ability was negatively related to statistics course anxiety and positively related to statistics achievement. Students with low mathematics ability perceived statistics courses as difficult; and their perception, in turn, strongly influences their level of statistics course anxiety. Trait worry had a significant direct effect on state worry, but not on state emotionality, and the same pattern occurred with trait-state emotionality. Trait worry, but not trait emotionality, was positively related to statistics course anxiety. Students reporting high statistics course anxiety perceived the final examination as difficult; however, statistics course anxiety had a significant effect on neither statistics achievement or state test anxiety. Students' perception of statistics course difficulty influenced their perception of test difficulty, which in turn had significant direct effects on both state worry and emotionality. As expected, achievement on statistics midterm examinations had a direct effect on state worry but not state emotionality. (Contains 2 figures, 2 tables, and 42 references.) (Author)

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Effects of Gender, Math Ability, Trait Test Anxiety, Statistics Course Anxiety, Statistics Achievement, and Perceived Test Difficulty on State Test Anxiety

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Abstract

A path analytic model of state test anxiety was tested in 169 college students who were enrolled in statistics courses. Variables in the model included gender, math ability, trait test anxiety (trait worry and trait emotionality as separate variables), statistics course anxiety, statistics achievement (scores on midterm exams), perceived test difficulty, and state test anxiety (state worry and state emotionality) measured at the time the final exam was taking place. Female students reported higher trait test anxiety and statistics course anxiety than did males. Math ability was negatively related to statistics course anxiety and positively related to statistics achievement. Students with low math ability perceived statistics course as difficult, which in turn strongly influenced their level of statistics course anxiety. Trait worry had a significant direct effect on state worry but not on state emotionality, and the same pattern occurred with trait-state emotionality. Trait worry, but not trait emotionality, was positively related to statistics course anxiety. Students reporting high statistics course anxiety perceived the final exam as difficult; however, statistics course anxiety had a significant effect neither on statistics achievement nor on state test anxiety. Students' perception of statistics course difficulty influenced their perception of test difficulty, which in turn had significant direct effects on both state worry and emotionality. As expected, achievement on statistics midterm exams had a direct effect on state worry but not on state emotionality.

Effects of Gender, Math Ability, Trait Test Anxiety, Statistics Course Anxiety, Statistics Achievement, and Perceived Test Difficulty on State Test Anxiety

Students in most universities are required to take statistics courses, and a large number of these students have reported experiencing statistics course anxiety and test anxiety when enrolled in these courses (Fitzgerald, 1998; Onwuegbuzie, Da Ros, & Ryan, 1997; Zeidner, 1991). Anxiety about statistics course can result in deferring taking required statistics courses until just before graduation or in avoidance of statistics courses necessary for future professional advancement. High levels of students' perception of statistics test difficulty and statistics test anxiety can also have negative effects on statistics test performance.

Studies have investigated the relationship of test anxiety with such constructs as perception of test difficulty (Hong, 1999; Kim & Rockin, 1994), subject matter difficulty (Everson, Tobias, Hartment, & Gourgey, 1993), and prior experience in mathematics (Fitzgerald, 1998; Lussier, 1996). Most of these studies, however, focused on one or two of these constructs and examined them using univariate analyses. The current path analytic study investigated the simultaneous impacts of these constructs on state test anxiety (i.e., statistics test anxiety in the current study). The study included the two dimensions of trait test anxiety (i.e., trait worry and trait emotionality) to examine their differential effects on the corresponding dimensions of state test anxiety (i.e., state worry and state emotionality). In the section that follows, empirical findings on the relationships among gender, math ability, trait and state test anxiety, statistics course anxiety, statistics achievement, and perceived test difficulty, where available, are presented.

The worry versus emotionality distinction (Liebert & Morris, 1967) has been evidenced by factorial validation studies (e.g., Benson & Tippets, 1990) and by their differential effects on performance (e.g., Zeidner & Nevo, 1992). Worry refers to the cognitive concern about test-taking and performance, such as negative expectations, preoccupation with performance, and potential consequences. Emotionality refers to perceived physiological reactions, that is, autonomic arousal and somatic reactions to testing

situations such as nervousness and tension (Liebert & Morris, 1967; Morris et al., 1981; Schwarzer, 1984). The significant relationship between worry and emotionality within a testing occasion and between different testing occasions (e.g., Hong, 1999) and the relationship between trait and state test anxiety have been documented (e.g., Hong, 1998; O'Neil & Abedi, 1992).

State test anxiety refers to transitory, anxious affect state provoked by a specific evaluative situation, while trait test anxiety refers to the tendency to be anxious in any evaluative situations. State test anxiety was less stable than trait test anxiety; even when the factorial structures of state test anxiety were stable over time and the test-retest stability was high, individual state test anxiety was unstable across time (Hong, 1998). In addition, students with higher trait test anxiety experienced higher state test anxiety than did their counterparts with low trait anxiety (Head & Knight, 1988; Hong, 1998). However, the differential effects of trait worry and emotionality on state worry and emotionality have not been investigated simultaneously with other variables that might influence state test anxiety.

One of the reasons for students' heightened statistics course anxiety is mathematics anxiety that is transferred to statistics course. Observations of students' conversations in statistics classes have consistently suggested that students relate their apprehension at taking a statistics class to their lack of mathematical ability (e.g., how long it had been since they took mathematics courses). Wilson (1997) found that mathematics preparation and perception of mathematics ability significantly predicted statistics course anxiety. However, no substantial evidence for a significant relationship between students' anxiety in learning statistics and mathematics background was indicated in Sutarso (1992). The findings on the relationship between mathematics ability and statistics achievement also vary. While Perney and Ravid (1990) found no relationship between mathematics background and statistics course performance, in Goldstein and High's study (1992) mathematics ability measured by mathematics Scholastic Aptitude Test score was found be a significant determinant of success in statistics.

Empirical studies on gender difference in mathematics ability have reported conflicting findings as well in elementary and secondary levels, reporting from a significant gender difference (Cahan & Ganor, 1995; Fennema, 1984; Martin & Hoover, 1987; Seegers & Boekaerts,

1996) to no difference (Caporrimo, 1990; Senk & Usiskin, 1983), and to pattern changes in the gender difference indicating that girls' math achievement over the last decade seems to be improving relative to that of boys (Marsh & Yeung, 1998). At the college level, studies have shown lack of any significant gender difference in mathematical ability (Cooper & Robinson, 1989; Van Blerkom, 1985).

It is conceivable that strong anxiety effects may manifest in academic situations where a clear evaluative threat is perceived by students. Hembree (1988) indicated that students' perceptions of test difficulty in various subject matter areas were related to their anxiety about those subject matters. The perceived subject matter difficulty was positively related to test anxiety scores, independent of the particular subject and the test demands (Everson et al., 1993).

To determine whether worry and emotionality have differential levels of association with the perceived test difficulty, students' reported level of perceived test difficulty was related to the two components of test anxiety (Hong, 1999); while the perception of test difficulty was highly related to both worry and emotionality, a stronger relationship was shown with worry than with emotionality. However, whether statistics course anxiety would have an influence on statistics test anxiety (state test anxiety) has not been studied.

Based on these rather conflicting findings and the investigator's knowledge of the theoretical and conceptual aspects of text anxiety, it was hypothesized that mathematics ability would influence statistics course anxiety, perception of statistics course difficulty, and statistics achievement (midterm exams). Mathematical ability was also hypothesized to influence indirectly the perceived test difficulty and state worry and emotionality during the statistics final exam through its relationship with perceived statistics course difficulty or midterm exam achievement. A nonsignificant relationship between gender and math ability was predicted. It was also hypothesized that high perceived statistics course difficulty would be associated with high course anxiety and perceived test difficulty, while it would be negatively related to statistics achievement. It was further hypothesized that statistics course anxiety would influence the level of perceived test difficulty as well as statistics test anxiety (state worry and state emotionality).

Gender differences in test anxiety have been evidenced in numerous studies, with males reporting lower anxiety than females (Bander & Betz, 1981; Benson, Bandalos, & Hutchinson, 1994; Hembree, 1988; Lussier, 1996; Salamé, 1984; Sowa & Lafleur, 1986). While there have been no dearth of studies on the gender-test anxiety relationship, the relationship of gender with statistics course anxiety has been rarely examined. The two studies investigated this relationship reported conflicting results; one (Sutarso,1992) found no significant relationship between gender and anxiety in statistics learning, and the other (Demaria-Mitton, 1987) reported that women showed higher levels of statistics anxiety. Although insufficient evidence has been accumulated on this relationship, in the current study, women were hypothesized to have higher levels of statistics course anxiety as well as trait worry and emotionality than men because of the general trend of women reporting higher anxiety.

In sum, the current study tested a model of relationships among the constructs of gender, math ability, trait test anxiety, statistics course anxiety, statistics achievement (midterm exams), perceived test difficulty of the final statistics exam, and state test anxiety during the statistics final exam. The two dimensions of test anxiety--worry and emotionality--were tested separately to examine the differential effects of trait worry and emotionality to state worry and emotionality. Figure 1 shows the model that depicts the hypothesized relationships among the variables investigated in this study. It should be noted that relationships of certain variables with conflicting empirical findings were all included in the proposed model so they can be examined with the current data.

Insert Figure 1 about here

Method

Participants and Procedure

The 169 Students, 84 males and 85 females, enrolled in two graduate- (13 males and 30 females) and four undergraduate-level (71 males and 55 females) statistics courses at a large western university volunteered to participate in the study. The undergraduate students

represented diverse majors including economics, business, marketing, finance, management, engineering, accounting, biology, environmental studies, anthropology, leisure study, nursing, history. The graduate students were from the college of education.

Data were collected from surveys administered during two semesters. In both semesters, the initial survey (see Measures) was administered during the first two weeks of class. The second survey (see Measures) was administered on the day of the final examination. No remuneration or extra credit was provided. Appropriate informed consent was obtained, and students were assured anonymity. Only those students who had complete data from both surveys were included in the sample of 169.

Measures

The initial survey included background information (gender, major, degree objective), trait test anxiety (trait worry and trait emotionality), statistics course anxiety, perceived statistics course difficulty, and a quiz on math fundamentals. The second survey included two questionnaires, which were attached to the final examination, one on top and the other at the bottom of the test. The questionnaire on top measured perceived test difficulty, and the one at the bottom measured state test anxiety (state worry and state emotionality). These measures are described in the following section.

Trait test anxiety. A modified version of Test Anxiety Inventory (TAI; Spielberger, 1980) was employed to measure participants' trait test anxiety. It consisted of eight items, with four items measuring worry and four emotionality. Participants were asked to rate their test anxiety in general and responded to each item by rating themselves on the following four-point scale: (1) Almost never, (2) Sometimes, (3) Often, and (4) Almost always. Thus, trait test anxiety were measured on a frequency dimension, with low/high scores indicating low/high level of test anxiety in general task-oriented situations that are relatively stable over time.Examples of trait worry and trait emotionality items are, "Thoughts of doing poorly interfere with my concentration on tests" and "While taking examinations, I have an uneasy, upset feeling," respectively.

These items have been used in numerous studies, and their reliability and validity have been established in those studies (e.g., Hong, 1998; O'Neil & Abedi, 1992; O'Neil & Fukumura, 1992). The internal consistency estimates (coefficient alpha) for the trait worry and trait emotionality subscales in this study were .83 and .87. Scores on trait worry and trait emotionality ranged from 4 to 15 and from 4 to 16, with means and standard deviations (in parentheses) of 7.90 (2.67) and 8.54 (2.97), respectively.

Statistics course anxiety. An item measuring students' anxiety level for the statistics class was included in the initial survey. Participants were asked to rate their anxiety level for the statistics course on a nine-point scale: 0 (none), 1, 2 (low), 3, 4 (some), 5, 6 (much), 7, and 8 (terror). Scores ranged from 0 to 8, with a mean and a standard deviation of 4.43 and 1.91, respectively.

Perceived statistics course difficulty. Four items measuring the level of perceived statistics course difficulty was included in the initial survey. An example of the items was: "Compared to other subjects, how difficult do you feel this statistics course would be" (1 = very difficult; 2 = fairly difficulty; 3 = fairly easy; 4 = very easy). The internal consistency estimate for this scale was .70. Scores ranged from 4 to 16, with a mean and a standard deviation of 11.35 and 2.12, respectively.

Mathematics ability. A quiz on 47-item mathematics fundamentals was administered with the initial survey. It consisted of 33 items on fundamental operations and 14 items on simple algebra. The scores ranged from 10 to 47, with a mean and a standard deviation of 36.21 and 7.98, respectively. Students took the quiz after they filled out the aforementioned initial survey.

Perceived test difficulty. Two items measuring students' perceived test difficulty were attached on top of the final examination. Students were asked to respond to the items before they see the test items. The two items were: "Compared to other subjects, this statistics exam will be difficult" and "I think this exam will be a difficult one for me." Participants rated themselves on the following four-point scale: (1) Not at all, (2) Somewhat, (3) Moderately so, and (4) Very Much So. The internal consistency estimate for this scale

was .70. Scores ranged from 2 to 8, with a mean and a standard deviation of 5.73 and 1.56, respectively.

State test anxiety. A modified version of Test Anxiety Inventory (TAI; Spielberger, 1980) was employed to measure participants' state worry and state emotionality. Eight items, with four items measuring worry and four emotionality, were attached at the bottom of the final exam, asking students to respond to the questions after they completed their exam and to indicate how they thought or felt during the test. Participants responded to each test anxiety item by rating themselves on the following four-point scale: (1) Not at all, (2) Somewhat, (3) Moderately so, and (4) Very Much So. Thus, the test anxiety scale defines a continuum of increasing levels of intensity in test anxiety, with low scores indicating low level of test anxiety and high scores indicating states of intense test anxiety. Examples of state worry and state emotionality items are, "I was concerned about what would happen if I did poorly" and "While taking the exam, I had an uneasy, upset feeling," respectively.

Again, these items have been used in numerous studies, and their reliability and validity have been established (e.g., Hong, 1998; O'Neil & Abedi, 1992; O'Neil & Fukumura, 1992). The internal consistency estimates for the state worry and state emotionality subscales were .90 and .93, respectively. Scores ranged from 4 to 16 for both state worry and state emotionality, with means and standard deviations (in parentheses) of 8.63 (3.68) and 7.42 (3.41), respectively.

Statistics achievement. In the proposed model, statistics achievement was hypothesized to influence the perceived test difficulty of the final exam and state worry and state emotionality during the final exam. Although all midterm exam scores and a final exam score were collected from each participating student, only midterm exam scores were used in this study since the main purpose of the investigation was to determine the variables (including statistics achievement scores on midterm exams) that influence state test anxiety during the final exam.

In the two graduate classes taught by the same instructor, the maximum possible score for the combined midterm scores was 100, with a mean and a standard deviation of 82.58 and 8.79,

respectively. All four undergraduate classes had three midterm exams. In the three of these undergraduate classes, the maximum possible score of each midterm exam was 100, and the average of these three scores was used as the midterm exam score. In one undergraduate class, the maximum possible score for the three midterm exams was 90 (30 points per exam); however, the instructor of this class used the percentage scores (maximum score of 100) for grading. Using the maximum possible score as 100, the undergraduate midterm exam scores ranged from 48 to 98, with a mean and a standard deviation of 79.56 and 10.74, respectively. Because the exam scores were scaled similarly in these classes, and the means and variations of the graduate and undergraduate exam scores were relatively comparable, a standardization procedure was not applied to these scores.

Data Analysis

The standard path analysis technique is used to examine the direct and indirect effects between variables. As a tool for theoretical clarification, the technique is considered appropriate when one maps the probable causal links among the variables present, based on one's theoretical, empirical, and commonsense knowledge of a problem (Cook & Campbell, 1979).

The proposed path model (Figure 1) was tested by the EQS program (Bentler, 1995). Although EQS is used primarily for testing structural models that include both observed and latent variables, testing standard path analysis models by EQS can benefit from some of the program's test statistics. The main features of the EQS used in this standard path analysis study were the Wald and Lagrange Multiplier (LM) tests (Bentler, 1995). The Wald test evaluates whether some of the free parameters in the model could be restricted, while the LM test is used to evaluate the statistical necessity of the restrictions, that is, whether some of the fixed parameters in the model could be freed. Other features that are more appropriate to the latent model testing were not reported in this article. Table 1 presents the covariances and correlations among the 10 variables examined in the study.

Insert Table 1 about here

Results

Initial Model

An initial test of the hypothesized path model (Figure 1) resulted in several nonsignificant paths. It also revealed a few significant paths that were not hypothesized to be significant. Examinations of the findings from the multivariate Wald test indicated that nine parameters hypothesized to be significant were nonsignificant empirically, ps > .05. These paths included: math ability to statistics course anxiety; trait worry to state emotionality; trait emotionality to statistics course anxiety and to state worry; perceived statistics course difficulty to statistics achievement; statistics course anxiety to statistics achievement (midterm exams) and to state worry and emotionality; and statistics achievement to state emotionality.

The multivariate LM test suggested four parameters to be added. They were all associated with math ability, i.e., the relationship of math ability' with trait and state worry and emotionality.

Model Modifications

Alternative models were reestimated by deleting paths with nonsignificant t values and adding significant paths that were not originally included in the proposed model. This post hoc model modification with the Wald and LM tests might pose a problem because the procedure may make the model look better than it actually is (Bentler & Wu, 1995). In testing alternative models, however, modifications (addition or deletion of paths) were carried out based on theoretical as well as statistical considerations. For example, both trait worry and emotionality test anxiety were initially hypothesized to have direct effects on both state worry and emotionality based on the significant correlations found among trait and state measures of worry and emotionality in previous studies. However, the paths from trait worry to state emotionality and from trait emotionality to state worry were deleted in the alternative model tested, not only because of the statistical findings from the analysis of the initial model but because it is highly plausible that a direct effect of a component of trait

test anxiety (worry or emotionality) can be found only on the corresponding state test anxiety, especially with a simultaneous test of relationships that was not conducted previously.

Inspections of the nonsignificant parameters indicated that these nonsignificant findings in the current sample were associated with the previous findings that were inconsistent across studies, and some of the relationships have not been investigated. For example, while the relationship between the subject matter anxiety and test anxiety have been investigated, the worry and emotionality components of test anxiety have not been tested separately to investigate the relationship of these with subject matter anxiety (statistics course anxiety). Since the paths with inconsistent empirical findings in previous research were all included in the initial model, that these nonsignificant paths were found in the current study was not surprising.

With the aforementioned observations, the nonsignificant paths were removed from the model simultaneously (based on the results from the simultaneous process of multivariate Wald test). Removing these paths did not result in the elimination of any significant indirect effects. The test results of this alternative model still suggested that the four parameters mentioned above be added, while there was no additional suggestion for a removal of any parameters. Because the trait test anxiety items asked the participants to respond to the questions regarding their test anxiety in general (e.g., "I feel very panicky when I take an important test"), the suggested paths from math ability to trait test worry and emotionality were not expected to be significant. However, because the questionnaire was administered at the beginning of the statistics course, students might have related the questions to statistics- or math-related tests in general, resulting in high correlations among those variables. Thus, four paths were decided to be added to the next alternative model.

With the four additional parameters and removal of aforementioned nine parameters, this alternative model was tested. The test results conformed to those suggested from the previous alternative model testing, except for two parameters now reversed in their significance tests: The path from math ability to statistics course anxiety became significant,

$p < .05$, and the path from math ability to state worry anxiety became nonsignificant, $p > .05$. These findings, which do not have established theoretical supports, were incorporated in the final model.

Final Model

The final model with the standardized path coefficients on the significant paths is provided in Figure 2. Table 2 summarizes direct and indirect effects of variables presented in the final model. Also provided in Table 2 are variance explained (R^2) and residual path coefficients that represent factors that influence a particular dependent variable but were not included in the model.

Insert Figure 2 about here

Insert Table 2 about here

Gender effects. Females in general reported higher anxiety in trait worry ($\beta = .16$, $p < .05$), trait emotionality ($\beta = .23$, $p < .01$), and statistics course anxiety ($\beta = .15$, $p < .05$). However, in other variables including state test anxiety, significant gender effects were not found.

Effects of math ability. Math ability had direct effects on both trait worry ($\beta = -.21$, $p < .01$) and trait emotionality ($\beta = -.30$, $p < .001$), indicating that students with high math ability reported lower levels of trait test worry and emotionality. Math ability also showed an indirect effect on state emotionality ($\beta = -.19$, $p < .05$) through its influence on various mediating variables; however this effect was mostly due to its relationship with trait emotionality ($\beta = -.15$, $p < .05$). Math ability had a direct positive effect on state emotionality ($\beta = .15$, $p < .05$), an interesting phenomenon that students with high math ability showing high state emotionality.

Math ability not only directly influenced the statistics course anxiety (β = -.13, p < .05), but also had an indirect effect on the latter through its influence on perceived statistics course difficulty (β = -.15, p < .05), indicating that students with low mathematics ability reported having high course difficulty perception, which in turn influenced their course anxiety. Finally, math ability had a significant direct effect on the statistics midterm exam performance (β = .30, p < .001).

Effects of trait worry and trait emotionality. Trait worry had a direct effect on state worry (β = .35, p < .001) and statistics achievement on midterm exams (β = -.27, p < .001). Trait emotionality, on the other hand, had direct effects on state emotionality (β = .49, p < .001) and statistics achievement (β = .16, p < .05). These findings indicated that trait worry or emotionality had a significant association only on its corresponding state worry or emotionality. In addition, while trait worry negatively influenced the statistics performance as expected, the trait emotionality had a positive effect on the latter, indicating that students who reported having high trait emotionality did better in the midterm exams. Earlier in the analyses of math ability effects, high state emotionality was also associated with high math ability.

Trait worry (β = .19, p < .01) but not trait emotionality influenced the statistics course anxiety. No indirect effects were found with trait worry and emotionality.

Effects of perceived course difficulty and course anxiety. Students with a high level of perceived statistics course difficulty also reported having a high level of course anxiety (β = .47, p < .001) and perceived test difficulty of the final statistics exam (β = .26, p < .01). However, the former did not influence statistics achievement. Statistics course anxiety had a direct effect on the perceived test difficulty on the final exam (β = .18, p < .05), but no effect on midterm statistics achievement. No indirect effects of course difficulty and course anxiety perceptions were indicated.

Effects of statistics achievement and perceived test difficulty. The midterm exam scores influenced the way students perceived the test difficulty and statistics test anxiety. Statistics achievement on midterm exams negatively affected the test difficulty perception (β

= -.16, $p < .05$) and state worry anxiety ($\beta = -.22$, $p < .001$) during the final exam, but not state emotionality. The test difficulty perception of the final exam had direct effects on both state worry ($\beta = .34$, $p < .001$) and state emotionality ($\beta = .22$, $p < .001$).

Variance explained (R^2) for each equation ranged from .07 to .39 (see Table 2). The one variable with less than 10% of explained variance was trait worry anxiety predicted by gender and math ability. The large unexplained variations in some of the dependent variables indicate that there are other relevant variables not included in the model, suggesting further research with test anxiety-related variables to fully understand student anxiety in statistics courses.

Discussion

Students often take statistics courses with a high level of anxiety and apprehension. Anxiety of test-taking and lack of understanding of statistics have been found to be the highest sources of anxiety in statistics (Zanakis & Valenzi, 1997). Onwuegbuzie, Da Ros, and Ryan (1997) indicated that statistics anxiety also occurs when a student experiences anxiety as a result of encountering statistics in any form. The current study helps us understand the factors that influence various anxiety of students in statistics courses.

Gender showed significant effects on three anxiety measures (trait worry, trait emotionality, statistics course anxiety), although their effect sizes were relatively small. As evidenced in numerous studies (e.g., Lussier, 1996), female students reported higher trait test anxiety than did males. Unlike the finding in Sutarso (1992), where no significant relationship was found between gender and statistics anxiety, females reported higher statistics course anxiety than did males (Demaria-Motton, 1987). However, with the standardized regression coefficient of only .15 with the .05 level of significance, this relationship warrants further investigations. The nonsignificant gender effects on state (statistics) test anxiety are noteworthy. Although a gender difference was found in general trait test anxiety, when students took the statistics final exam, male and female students did not differ in the degree of statistics test anxiety.

As indicated in the studies with college students that showed no gender difference on math ability (e.g., Cooper & Robinson, 1989), the current study supports the contention that male and females students who enter a college level education may no longer show significant differences in their math ability. However, this interpretation may only apply to students who take certain courses.

Math ability had numerous significant direct as well as indirect effects with standardized regression coefficients larger than or equal to .30. Thus, math ability is an important factor to be considered for understanding student anxiety in statistics classes. The findings in general support the view that heightened anxiety in taking statistics course may be transferred from mathematics anxiety.

Wilson (1997) and Sutarso (1992) reported conflicting findings on the relationship between mathematics background and statistics course anxiety. The current findings support the former study with a negative relationship between the two constructs; however, the effect was not substantial (β = -.13), requiring more replication studies for further clarification. Although the relationship between mathematics ability and statistics achievement have been inconsistent, the current study supported the finding by Goldstein and High (1992), with a relatively strong indication of positive relationship (β = .30). Fitzgerald (1998) also found that after controlling for past experiences in math, statistics anxiety was no longer related to statistics achievement. Based on these findings, it appears that students who may be at risk of performing poorly in statistics classes might benefit from an intervention focusing on mathematics skill development. That students with high math ability did not perceive their statistics course as difficult as their peers with low math ability, also adds to our understanding on math ability and its correlates.

Trait worry had a significant direct effect on state worry but not on state emotionality. Likewise, trait emotionality had a significant direct effect on state emotionality but not on state worry. That is, unlike the significant correlations found among all four measures from univariate analyses (e.g., Hong, 1999), the current path analytic study showed that the level of each trait test anxiety component (worry or emotionality) influence

only the level of corresponding component of state test anxiety. These findings suggest that simple correlation analyses may not reveal the underlying relationships as accurately as the simultaneous tests of relationships among variables.

Trait worry, compared to trait emotionality, showed stronger effects on statistics achievement (-.27 vs. .16). This finding is in accordance with the previous findings where worry consistently showing stronger effects on achievement compared to emotionality (e.g., Kim & Rocklin, 1994; Zeidner & Nevo, 1992). In addition, trait worry, but not trait emotionality influenced statistics course anxiety, indicating that the cognitive component (worry) is the influencing component on anxiety of statistics learning.

However, the direction of the effects on the two findings with emotionality needs an attention. Trait emotionality in this study had a positive effect on the statistics midterm exam performance, and math ability also had a positive effect on state emotionality. These two findings may indicate that heightened emotionality--autonomic arousal and somatic reactions to testing situations such as nervousness and tension--may not be a hindrance to test-taking, but might even help students focus on solving statistical problems. In a study by Bandalos, Yates, and Thorndike-Christ (1995), a positive relationship between the number of prior math courses and general emotionality test anxiety was also found. They conjectured that it might have been due to less than positive experiences in those courses. However, math ability in the current study was represented by scores on math fundamentals. Although Bandalos et al.'s (1995) reasoning does not hold in the current study, the findings on the positive relationship of emotionality with related variables in both studies are worthy of an attention and further examinations. Interviews with a sample of students who report high in emotionality, but also score high in math or statistics, would be a worthwhile investigation that would shed more light on this rather unexpected relationship.

As Hembree (1988) indicated, students who perceived their statistics course difficult in the current study also reported high course anxiety and high perceived test difficulty. Interestingly, however, neither the level of perceived statistics course difficulty nor course anxiety had an effect on statistics performance; it was trait test anxiety and math ability that

had impacts on statistics achievement. In addition, statistics anxiety did not have a direct influence on either state worry or state emotionality, leaving only one significant path to perceived test difficulty. This may indicate that statistics course anxiety measured early in the course semester may have less relevance to the midterm performance and anxiety levels during the final exam; that is, students' statistics anxiety level might have been altered by the feedback students were receiving during the course. The relationship between the level of temporal changes in statistics course anxiety during the course and test anxiety during midterm and final exams would be an interesting topic for future studies. Statistics course anxiety was measured with one item in this study. Although this nine-point-scale item seemed to have face validity and appropriate variability, this could have been problematic in the model testing.

Unlike the finding by Everson et al. (1993), the perceived course difficulty did not directly influence state test anxiety, but the former influenced the test difficulty perception, which in turn had a significant direct effect on both state worry and emotionality. Thus, it was the perception of test difficulty that directly heightened statistics test anxiety (state worry and emotionality), rather than the perception of course difficulty. Again, the effect of perceived test difficulty was stronger on state worry (.34) than on state emotionality (.22).

Achievement on the statistics midterm exams influenced state worry directly but not state emotionality. This supports the contention that worry anxiety--the cognitive concern about performance--was influenced by the performance on the midterm exams, but emotionality was not. As expected, students who scored high on the midterm exams perceived the final exam to be not as difficult as their low-achieving counterparts.

The plausibility of postulated relations among variables in a model may be examined more efficiently with the structural equation modeling (SEM) with both observed and latent variables. Among the advantages in using the SEM over standard path analytic model are nonrecursive models can be tested and estimates of the relationships among variables that are corrected for measurement error can be obtained. Future research with various antecedents of test anxiety should be tested by the SEM.

Class standing might have different effects on test anxiety. Bandalos et al. (1995), Benson and Bandalos (1989), and Benson et al. (1994) found that undergraduate students reported higher levels of general test anxiety than did graduates, while no differences in the levels of statistics test anxiety were found. Due to the sample size in the current study, the effects of class standing was not tested. With proper sample size, one may test whether a model obtained from the total sample would fit equally well for both groups using multi-sample analyses provided in SEM statistical programs. Self-efficacy and effort in statistics learning and test-taking may also be good variables to examine to better understand the relationships of these with anxiety in statistics courses.

In sum, the findings from the current study demonstrate what might influence students' test anxiety. While the study could not include all the possible variables that might cause students' test anxiety, it depicts a more comprehensive picture of the test anxiety phenomenon when compared to univariate studies. Due to the relatively small sample size, model modifications were made in a post hoc fashion on the same sample on which the hypothesized model was tested. Although findings of this study replicated many of those in previous studies and appear to be consistent with the current theory on test anxiety, some different as well as new findings were also revealed. Whether these new findings can be generalized would depend on further replication studies.

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Table 1

Covariance and Correlation Matrix of the 10 Variables Examined

Variables	1	2	3	4	5	6	7	8	9	10
1. Gender	0.25	-0.04	0.10	0.22	0.17	0.24	0.06	0.10	0.01	0.08
2. Math	-0.16	56.03	0.32	-0.31	-0.22	-0.30	-0.31	-0.11	-0.09	-0.03
3. StatAch	0.51	25.03	106.97	-0.11	-0.22	-0.14	-0.13	-0.20	-0.36	-0.22
4. StatAnx	0.20	-4.39	-2.21	3.49	0.39	0.39	0.56	0.34	0.37	0.32
5. TRWO	0.22	-4.22	-5.82	1.84	6.51	0.76	0.33	0.20	0.46	0.39
6. TREM	0.34	-6.43	-4.08	2.05	5.44	7.99	0.30	0.24	0.42	0.49
7. StatDiff	0.07	-4.92	-2.81	2.23	1.78	1.78	4.50	0.37	0.35	0.23
8. TestDiff	0.08	-1.29	-3.28	0.99	0.81	1.06	1.24	2.45	0.46	0.32
9. STWO	0.02	-2.35	-13.63	2.51	4.32	4.30	2.67	2.60	13.31	0.74
10. STEM	0.13	-0.63	-7.35	1.95	3.26	4.56	1.57	1.63	8.89	10.84

Note. Covariances and correlations are presented in the lower left and upper right triangle, respectively; Gender 1 = male and 2 = female; StatAch = statistics achievement (midterm exam scores); StatAnx = statistics course anxiety; TRWO = trait worry; TREM = trait emotionality; StatDiff = perceived statistics course difficulty; TestDiff = perceived test difficulty on the final exam; STWO = state worry; STEM = state emotionality.

Table 2
Direct and Indirect Effects from the Final Model

Effect	Direct effect	Indirect effect	Total effect	Residual path coeff.	R^2	
On trait worry				.96		.07
of gender	.16*	.00	.16*			
of math ability	-.21**	.00	-.21**			
On trait emotionality				.93	.14	
of gender	.23**	.00	.23**			
of math ability	-.30***	.00	-.30***			
On stat. course diff.				.95	.10	
of math ability	-.31***	.00	-.31***			
On stat. course anx.				.80	.36	
of gender	.15*	.00	.15*			
of trait worry	.19**	.00	.19**			
of math ability	-.13*	-.15*	-.28***			
of stat. course diff	.47***	.00	.47***			
On stat. midterm ach.				.90	.19	
of trait worry	-.27***	.00	-.27***			
of trait emotionality	.16*	.00	.16**			
of math ability	.30***	.00	.30***			
On test difficulty				.91	.18	
of stat. course anx.	.18*	.00	.18*			
of stat. course diff.	.26**	.00	.26**			
of stat. midterm ach.	-.16*	.00	-.16*			
On state worry				.78	.39	
of trait worry	.35***	.00	.35***			
of test difficulty	.34***	.00	.34***			
of stat. midterm. ach.	-.22***	-.05 ns	-.27***			
On state emotionality				.85	.27	
of trait emotionality	.49***	.00	.49***			
of test difficulty	.22***	.00	.22***			
of math ability	.15*	-.19*	-.04 ns			

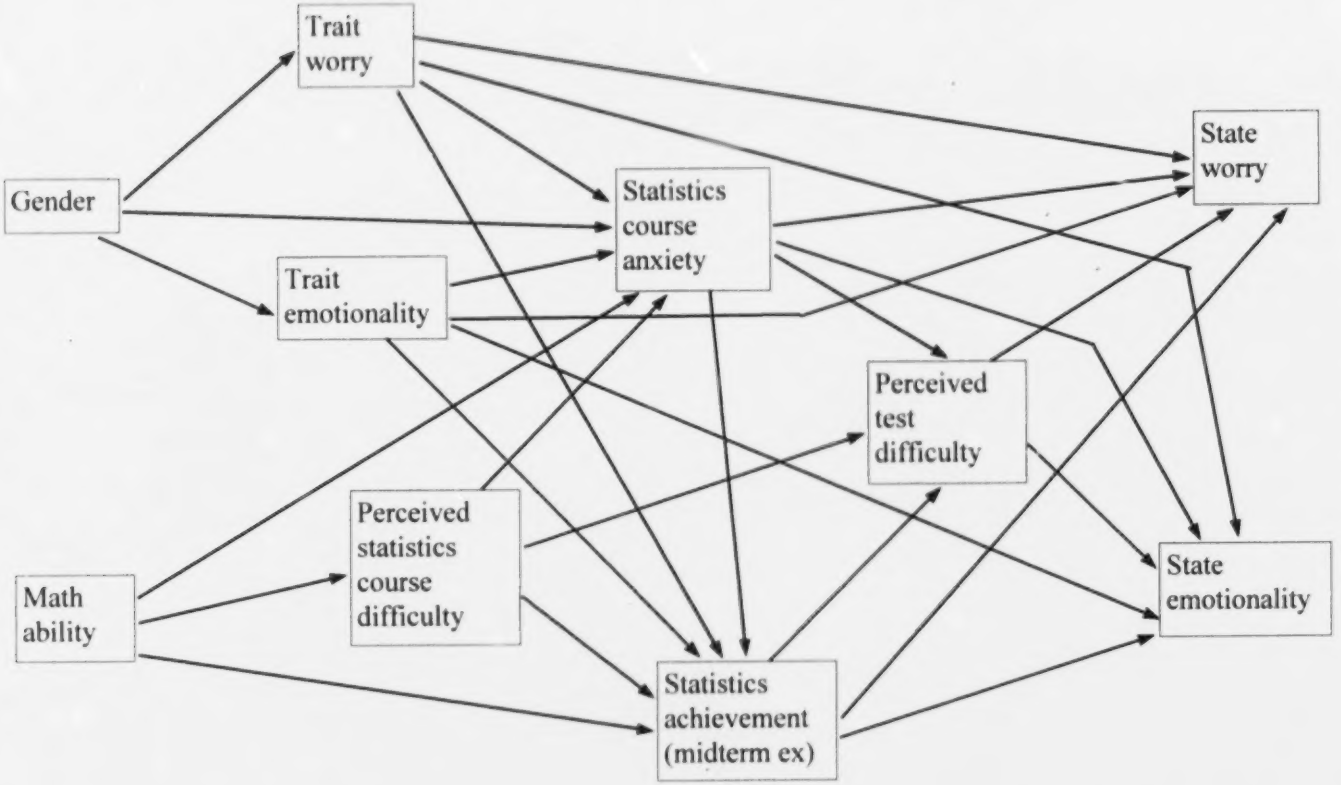
Note. For brevity, only those independent variables with either significant direct or indirect effect were listed in this table; β = Standardized path coefficient; stat. course diff. = perceived statistics course difficulty; stat. course anx. = statistics course anxiety; stat. midterm ach. = statistics midterm exam scores.

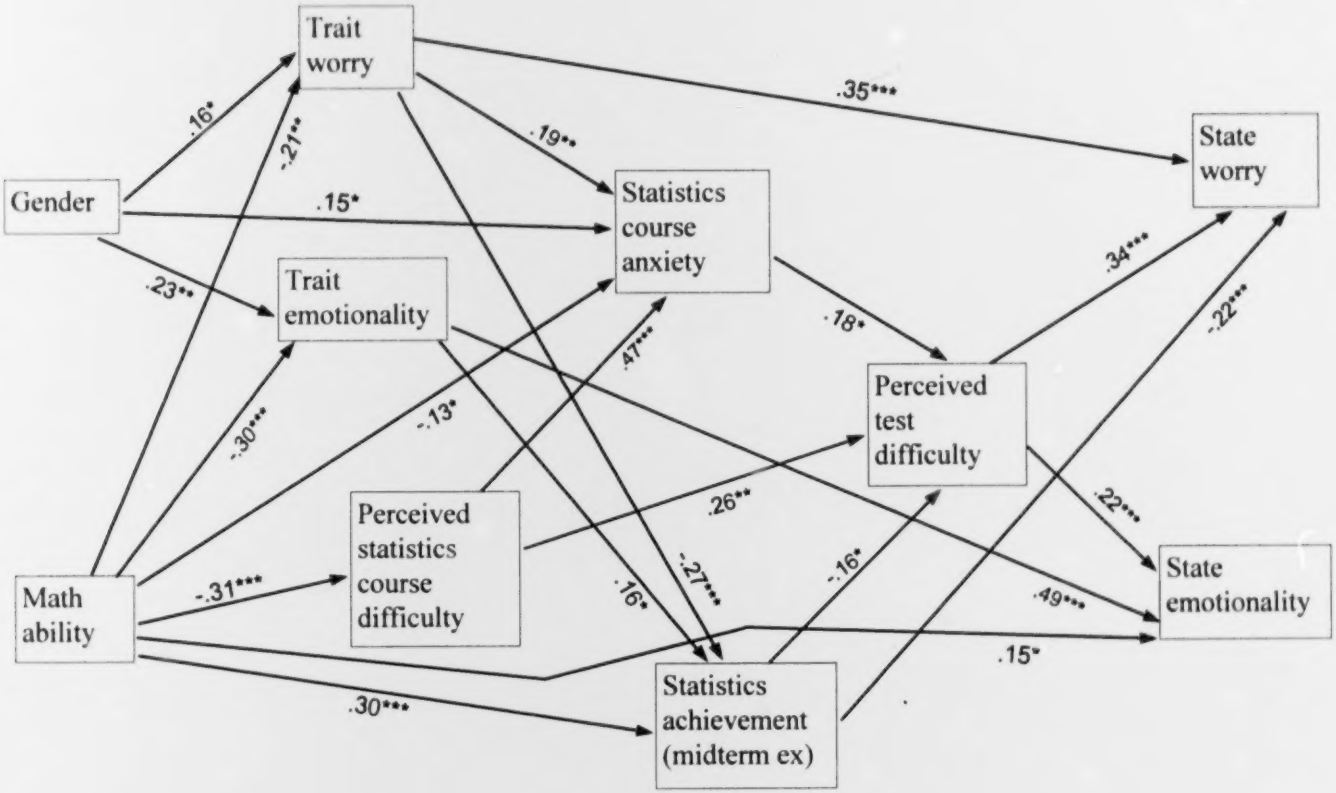
*p < .05. **p < .01. ***p < .001. ns = nonsignificant indirect effect.

Figure Captions

Figure 1. Initial hypothesized model.

Figure 2. Final model with standardized path coefficients.


Trait worry
Gender
Statistics course anxiety
State worry
Trait emotionality
Perceived test difficulty
Perceived statistics course difficulty
Math ability
State emotionality
Statistics achievement (midterm ex)


Trait worry
State worry
Gender
Statistics course anxiety
Trait emotionality
Perceived test difficulty
Perceived statistics course difficulty
State emotionality
Math ability
Statistics achievement (midterm ex)
.35***
.16*
-.21**
.19**
.15*
.23**
.34***
.18*
-.22***
-.30***
-.13*
.47***
.26**
-.31***
.16*
-.27***
-.16*
.49***
.22***
.15*
.30***

*p < .05. **p < .01. ***p < .001.